Annex C

Methodology for Estimating Emissions of CH_4, N_2O, and Criteria Pollutants from Mobile Sources

Estimates of CH_4 and N_2O Emissions from Mobile Combustion

Greenhouse gas emissions from mobile sources are reported by transport mode (e.g., road, rail, air, and water), vehicle type, and fuel. EPA does not systematically track emissions of CH_4 and N_2O; therefore, estimates of these gases were developed using a methodology similar to that outlined in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997).

Step 1: Determine Vehicle Miles Traveled or Fuel Consumption by Vehicle Type, Fuel Type, and Model Year

Activity data were obtained from a number of U.S. government agency publications. Depending on the category, these basic activity data included such information as fuel consumption, fuel deliveries, and vehicle miles traveled (VMT). The activity data for highway vehicles included estimates of VMT by vehicle type and model year from EPA (1997a) and the MOBILE5a emissions model (EPA 1997b).

National VMT data for gasoline and diesel highway vehicles are presented in Table C-1 and Table C-2, respectively. Total VMT for each highway category (i.e., gasoline passenger cars, light-duty gasoline trucks, heavy-duty gasoline vehicles, diesel passenger cars, light-duty diesel trucks, heavy-duty diesel vehicles, and motorcycles) were distributed across 25 model years based on the temporally fixed age distribution of VMT by the U.S. vehicle fleet in 1990 (see Table C-3) as specified in MOBILE5a. Activity data for gasoline passenger cars and light-duty trucks in California were developed separately due to the different emission control technologies deployed in that state relative to the rest of the country. Unlike the rest of the United States, beginning in model year 1994, a fraction of the California VMT for gasoline passenger cars and light-duty trucks was attributed to for low emission vehicles (LEVs). LEVs have not yet been widely deployed in other states. Based upon U.S. Department of Transportation statistics for 1994, it was assumed that 8.7 percent of national VMT occurred in California.

Activity data for non-highway vehicles were based on annual fuel consumption statistics by transportation mode and fuel type. Consumption data for distillate and residual fuel oil by ocean-going ships (i.e., marine bunkers), boats, construction equipment, farm equipment, and locomotives were obtained from EIA (1997). Data on the consumption of jet fuel and aviation gasoline in aircraft were obtained from FAA (1997). Consumption of motor gasoline by boats, construction equipment, farm equipment, and locomotives data were drawn from FHWA (1997). The activity data used for non-highway vehicles are included in Table C-4.

Step 2: Allocate VMT Data to Control Technology Type for Highway Vehicles

For highway sources, VMT by vehicle type for each model year were distributed across various control technologies as shown in Table C-5, Table C-6, Table C-7, Table C-8, and Table C-9. Again, California gasoline-fueled passenger cars and light-duty trucks were treated separately due to that state's distinct mobile source emission standards—including the introduction of LEVs in 1994—compared with the rest of the United States. The categories "Tier 0" and "Tier 1" have been substituted for the early three-way catalyst and advanced three-way catalyst categories, respectively, as defined in the *Revised 1996 IPCC Guidelines*. Tier 0, Tier 1, and LEV are actually U.S. emission regulations, rather than control technologies; however, each does correspond to particular combinations of control technologies and engine design. Tier 1 and its predecessor Tier 0 both apply to vehicles equipped with three-way catalysts. The introduction of "early three-way catalysts," and "advance three-way catalysts" as described in the *Revised 1996 IPCC Guidelines*, roughly correspond to the introduction of Tier 0 and Tier 1 regulations (EPA 1998).

Step 3: Determine the Amount of CH_4 and N_2O Emitted by Vehicle, Fuel, and Control Technology Type

Emissions of CH_4 from mobile source combustion were calculated by multiplying emission factors in IPCC/UNEP/OECD/IEA (1997) by activity data for each vehicle type as described in Step 1 (see Table C-10 and Table C-11). The CH_4 emission factors for highway sources were derived from EPA's MOBILE5a mobile source emissions model (EPA 1997b). The MOBILE5a model uses information on ambient temperature, diurnal temperature range, altitude, vehicle speeds, national vehicle registration distributions, gasoline volatility, emission control technologies, fuel composition, and the presence or absence of vehicle inspection/maintenance programs in order to produce these factors.

Emissions of N_2O—in contrast to CH_4, CO, NO_x, and NMVOCs—have not been extensively studied and are currently not well characterized. The limited number of studies that have been done on highway vehicle emissions of N_2O have shown that emissions are generally greater from vehicles with catalytic converter systems than those without such controls, and greater from aged than from new catalysts. These systems control tailpipe emissions of NO_x (i.e., NO and NO_2) by catalytically reducing NO_x to N_2. Suboptimal catalyst performance, caused by as yet poorly understood factors, results in incomplete reduction and the conversion of some NO_x to N_2O rather than to N_2. Fortunately, newer vehicles with catalyst and engine designs meeting the more recent Tier 1 and LEV standards have shown reduced emission rates of both NO_x and N_2O.

In order to better characterize the process by which N_2O is formed by catalytic controls and to develop a more accurate national emission estimate, the EPA's Office of Mobile Sources—at its National Vehicle and Fuel Emissions Laboratory (NVFEL)—recently conducted a series of tests in order to measure emission rates of N_2O from used Tier 1 and LEV gasoline-fueled passenger cars and light-duty trucks equipped with catalytic converters. These tests and a review of the literature were used to develop the emission factors for nitrous oxide used in this inventory (EPA 1998). The following references were used in developing the N_2O emission factors for gasoline-fueled highway passenger cars presented in Table C-10:

- *LEVs*. Tests performed at NVFEL (EPA 1998)[5]
- *Tier 1*. Tests performed at NVFEL (EPA 1988)
- *Tier 0*. Smith and Carey (1982), Barton and Simpson (1994), and one car tested at NVFEL (EPA 1998)
- *Oxidation Catalyst*. Smith and Carey (1982), Urban and Garbe (1979)
- *Non-Catalyst*. Prigent and de Soete (1989), Dasch (1992), and Urban and Garbe (1979)

Nitrous oxide emission factors for other types of gasoline-fueled vehicles—light-duty trucks, heavy-duty vehicles, and motorcycles—were estimated by adjusting the factors for gasoline passenger cars, as described above, by their relative fuel economies. This adjustment was performed using the carbon dioxide emission rates in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997) as a proxy for fuel economy (see Table C-10). Data from the literature and tests performed at NVFEL support the conclusion that light-duty trucks have higher emission rates than passenger cars. However, the use of fuel-consumption ratios to determine emission factors is considered a temporary measure only, to be replaced as soon as real data are available.

The resulting N_2O emission factors employed for gasoline highway vehicles are lower than the U.S. default values presented in the *Revised 1996 IPCC Guidelines*, but are higher than the European default values, both of which were published before the more recent tests and literature review conducted by the NVFEL. The U.S. defaults in the *Guidelines* were based on three studies that tested a total of five cars using European rather than U.S. test procedures. Nitrous oxide emission factors for diesel highway vehicles were taken from the European default values found in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997). There is little data addressing N_2O emissions from U.S. diesel-fueled vehicles, and in general, European countries have had more experience with diesel-fueled vehicles. U.S. default values in the *Revised 1996 IPCC Guidelines* were used for non-highway vehicles.

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5 It was assumed that LEVs would be operated using low-sulfur fuel (i.e., Indolene at 24 ppm sulfur). All other NVFEL tests were performed using a standard commercial fuel (CAAB at 285 ppm sulfur). Emission tests by NVFEL have consistently exhibited higher N_2O emission rates from higher sulfur fuels on Tier 1 and LEV vehicles.

Compared to regulated tailpipe emissions, there is relatively little data available to estimate emission factors for nitrous oxide. Nitrous oxide is not a criteria pollutant, and measurements of it in automobile exhaust have not been routinely collected. Further testing is needed to reduce the uncertainty in nitrous oxide emission factors for all classes of vehicles, using realistic driving regimes, environmental conditions, and fuels.

Estimates of NO_x, CO, and NMVOC Emissions From Mobile Combustion

The emission estimates of NO_x, CO, and NMVOCs for mobile sources were taken directly from the EPA's *National Air Pollutant Emissions Trends, 1900 - 1996* (EPA 1997a). This EPA report provides emission estimates for these gases by sector and fuel type using a "top down" estimating procedure whereby emissions were calculated using basic activity data, such as amount of fuel delivered or miles traveled, as indicators of emissions. Table C-12 through Table C-18 provide complete emissions estimates for 1990 through 1996.

Table C-1: Vehicle Miles Traveled for Gasoline Highway Vehicles (10^9 Miles)

Year	Passenger Cars[a]	Light-Duty Trucks[a]	Heavy-Duty Vehicles	Motorcycles	Passenger Cars (CA)[b]	Light-Duty Trucks (CA)[b]
1990	1362.75	422.09	43.32	9.57	129.86	40.22
1991	1381.11	428.12	43.60	9.20	131.61	40.80
1992	1437.57	431.76	43.39	9.55	136.99	41.14
1993	1462.88	450.30	45.96	9.89	139.40	42.91
1994	1426.55	531.21	49.67	10.25	135.94	50.62
1995	1466.04	545.90	51.04	10.52	139.70	52.02
1996	1492.35	555.84	52.00	10.73	142.21	52.97

[a] Excludes California
[b] California VMT for passenger cars and light-duty trucks was treated separately and estimated as 8.7 percent of national total.
Source: VMT data are the same as those used in EPA (1997a).

Table C-2: Vehicle Miles Traveled for Diesel Highway Vehicles (10^9 Miles)

Year	Passenger Cars	Light-Duty Trucks	Heavy-Duty Vehicles
1990	20.59	3.77	112.20
1991	20.87	3.84	112.91
1992	21.72	3.92	114.95
1993	22.09	4.08	119.61
1994	21.55	4.82	126.99
1995	22.14	4.95	130.50
1996	22.55	5.05	132.95

Source: VMT data are the same as those used in EPA (1997a).

Table C-3: VMT Profile by Vehicle Age (years) and Vehicle/Fuel Type for Highway Vehicles (percent of VMT)

Vehicle Age	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
1	4.9%	6.3%	2.3%	4.9%	6.3%	3.4%	14.4%
2	7.9%	8.4%	4.7%	7.9%	8.4%	6.7%	16.8%
3	8.3%	8.4%	4.7%	8.3%	8.4%	6.7%	13.5%
4	8.2%	8.4%	4.7%	8.2%	8.4%	6.7%	10.9%
5	8.4%	8.4%	4.7%	8.4%	8.4%	6.7%	8.8%
6	8.1%	6.9%	3.8%	8.1%	6.9%	7.3%	7.0%
7	7.7%	5.9%	3.3%	7.7%	5.9%	6.1%	5.6%
8	5.6%	4.4%	2.1%	5.6%	4.4%	4.0%	4.5%
9	5.0%	3.6%	2.6%	5.0%	3.6%	4.1%	3.6%
10	5.1%	3.1%	2.9%	5.1%	3.1%	5.1%	2.9%
11	5.0%	3.0%	3.4%	5.0%	3.0%	5.3%	2.3%
12	5.4%	5.3%	6.4%	5.4%	5.3%	6.6%	9.7%
13	4.7%	4.7%	5.4%	4.7%	4.7%	5.5%	0%
14	3.7%	4.6%	5.8%	3.7%	4.6%	5.7%	0%
15	2.4%	3.6%	5.1%	2.4%	3.6%	4.5%	0%
16	1.9%	2.8%	3.8%	1.9%	2.8%	1.9%	0%
17	1.4%	1.7%	4.3%	1.4%	1.7%	2.3%	0%
18	1.5%	2.2%	4.1%	1.5%	2.2%	2.8%	0%
19	1.1%	1.7%	3.5%	1.1%	1.7%	2.4%	0%
20	0.8%	1.4%	2.9%	0.8%	1.4%	1.6%	0%
21	0.6%	0.9%	2.1%	0.6%	0.9%	1.1%	0%
22	0.5%	0.8%	2.2%	0.5%	0.8%	0.9%	0%
23	0.4%	0.8%	2.2%	0.4%	0.8%	0.7%	0%
24	0.3%	0.5%	1.4%	0.3%	0.5%	0.5%	0%
25	1.0%	2.5%	11.7%	1.0%	2.5%	1.6%	0%

LDGV (gasoline passenger cars, also referred to as light-duty gas vehicles)
LDGT (light-duty gas trucks)
HDGV (heavy-duty gas vehicles)
LDDV (diesel passenger cars, also referred to as light-duty diesel vehicles)
LDDT (light-duty diesel trucks)
HDDV (heavy-duty diesel vehicles)
MC (motorcycles)

Table C-4: Fuel Consumption for Non-Highway Vehicles by Fuel Type (U.S. Gallons)

Vehicle Type/Year	Residual	Diesel	Jet Fuel	Other
Aircraft[a]				
1990	-	-	12,986,111,661	353,100,000
1991	-	-	11,995,880,426	353,600,000
1992	-	-	12,279,912,686	314,000,000
1993	-	-	12,326,549,428	268,400,000
1994	-	-	12,855,125,825	264,100,000
1995	-	-	13,140,841,990	258,100,000
1996	-	-	13,677,564,463	275,800,000
Marine Bunkers				
1990	4,686,071,250	549,251,000	-	-
1991	5,089,541,250	541,910,000	-	-
1992	5,399,308,500	560,042,500	-	-
1993	4,702,411,500	510,936,250	-	-
1994	4,458,628,500	506,724,750	-	-
1995	4,823,428,500	494,526,250	-	-
1996	4,353,732,750	544,402,000	-	-
Boats[b]				
1990	1,562,023,750	1,647,753,000	-	1,300,400,000
1991	1,696,513,750	1,625,730,000	-	1,709,700,000
1992	1,799,769,500	1,680,127,500	-	1,316,170,000
1993	1,567,470,500	1,532,808,750	-	873,687,000
1994	1,486,209,500	1,520,174,250	-	896,700,000
1995	1,607,809,500	1,483,578,750	-	1,060,394,000
1996	1,451,244,250	1,633,206,000	-	1,060,394,000
Construction Equipment[c]				
1990	-	2,508,300,000	-	1,523,600,000
1991	-	2,447,400,000	-	1,384,900,000
1992	-	2,287,642,000	-	1,492,200,000
1993	-	2,323,183,000	-	1,464,599,000
1994	-	2,437,142,000	-	1,492,152,000
1995	-	2,273,162,000	-	1,499,346,000
1996	-	2,386,973,000	-	1,499,346,000
Farm Equipment				
1990	-	3,164,200,000	-	812,800,000
1991	-	3,144,200,000	-	776,200,000
1992	-	3,274,811,000	-	805,500,000
1993	-	3,077,122,000	-	845,320,000
1994	-	3,062,436,000	-	911,996,000
1995	-	3,093,224,000	-	926,732,000
1996	-	3,225,029,000	-	926,732,000
Locomotives				
1990	25,422	3,210,111,000	-	-
1991	6,845	3,026,292,000	-	-
1992	8,343	3,217,231,000	-	-
1993	4,065	2,906,998,000	-	-
1994	5,956	3,063,441,000	-	-
1995	6,498	3,191,023,000	-	-
1996	6,498	3,266,861,000	-	-

- Not applicable

Sources: FWHA 1997, EIA 1997, and FAA 1997.

[a] Other Fuel = Aviation Gasoline.

[b] Other Fuel = Motor Gasoline

[c] Construction Equipment includes snowmobiles. Other Fuel = Motor Gasoline

Table C-5: Control Technology Assignments for Gasoline Passenger Cars (percentage of VMT)*

Model Years	Uncontrolled	Non-catalyst	Oxidation	Tier 0	Tier 1
≤1972	100%				
1973-1974		100%			
1975		20%	80%		
1976-1977		15%	85%		
1978-1979		10%	90%		
1980		5%	88%	7%	
1981			15%	85%	
1982			14%	86%	
1983			12%	88%	
1984-1993				100%	
1994				60%	40%
1995				20%	80%
1996					100%

* Excluding California VMT

Table C-6: Control Technology Assignments for Gasoline Light-Duty Trucks (percentage of VMT)*

Model Years	Uncontrolled	Non-catalyst	Oxidation	Tier 0	Tier 1
≤1972	100%				
1973-1974		100%			
1975		30%	70%		
1976		20%	80%		
1977-1978		25%	75%		
1979-1980		20%	80%		
1981			95%	5%	
1982			90%	10%	
1983			80%	20%	
1984			70%	30%	
1985			60%	40%	
1986			50%	50%	
1987-1993			5%	95%	
1994				60%	40%
1995				20%	80%
1996					100%

* Excluding California VMT

Table C-7: Control Technology Assignments for California Gasoline Passenger Cars and Light-Duty Trucks (percentage of VMT)

Model Years	Uncontrolled	Non-catalyst	Oxidation	Tier 0	Tier 1	LEV
≤1972	100%					
1973-1974		100%				
1975-1979			100%			
1980-1981			15%	85%		
1982			14%	86%		
1983			12%	88%		
1984-1991				100%		
1992				60%	40%	
1993				20%	80%	
1994					90%	10%
1995					85%	15%
1996					80%	20%

Table C-8: Control Technology Assignments for Gasoline Heavy-Duty Vehicles (percentage of VMT)

Model Years	Uncontrolled	Non-catalyst	Oxidation	Tier 0
≤1981	100%			
1982-1984	95%		5%	
1985-1986		95%	5%	
1987		70%	15%	15%
1988-1989		60%	25%	15%
1990-2003		45%	30%	25%
2004				100%

Table C-9: Control Technology Assignments for Diesel Highway VMT

Vehicle Type/Control Technology	Model Years
Diesel Passenger Cars and Light-Duty Trucks	
Uncontrolled	1966-1982
Moderate control	1983-1995
Advanced control	1996
Heavy-Duty Diesel Vehicles	
Uncontrolled	1966-1972
Moderate control	1983-1995
Advanced control	1996
Motorcycles	
Uncontrolled	1966-1995
Non-catalyst controls	1996

* California VMT only

Table C-10: Emission Factors (g/km) for CH_4 and N_2O and "Fuel Economy" (g CO_2/km)[c] for Highway Mobile Sources

Vehicle Type/Control Technology	N_2O	CH_4	g CO_2/km
Gasoline Passenger Cars			
Low Emission Vehicles[a]	0.0176	0.025	280
Tier 1	0.0288	0.030	285
Tier 0	0.0507	0.040	298
Oxidation Catalyst	0.0322	0.070	383
Non-Catalyst	0.0103	0.120	531
Uncontrolled	0.0103	0.135	506
Gasoline Light-Duty Trucks			
Low Emission Vehicles[a]	0.0249	0.030	396
Tier 1	0.0400	0.035	396
Tier 0	0.0846	0.070	498
Oxidation Catalyst	0.0418	0.090	498
Non-Catalyst	0.0117	0.140	601
Uncontrolled	0.0118	0.135	579
Gasoline Heavy-Duty Vehicles			
Tier 0	0.1729	0.075	1,017
Oxidation Catalyst[b]	0.0870	0.090	1,036
Non-Catalyst Control	0.0256	0.125	1,320
Uncontrolled	0.0269	0.270	1,320
Diesel Passenger Cars			
Advanced	0.0100	0.01	237
Moderate	0.0100	0.01	248
Uncontrolled	0.0100	0.01	319
Diesel Light Trucks			
Advanced	0.0200	0.01	330
Moderate	0.0200	0.01	331
Uncontrolled	0.0200	0.01	415
Diesel Heavy-Duty Vehicles			
Advanced	0.0300	0.04	987
Moderate	0.0300	0.05	1,011
Uncontrolled	0.0300	0.06	1,097
Motorcycles			
Non-Catalyst Control	0.0042	0.26	219
Uncontrolled	0.0054	0.13	266

[a] Applied to California VMT only

[b] Methane emission factor assumed based on light-duty trucks oxidation catalyst value

[c] The carbon emission factor (g CO_2/km) was used as a proxy for fuel economy because of the greater number of significant figures compared to the km/L values presented in (IPCC/UNEP/OECD/IEA 1997).

NA (Not Available)

Table C-11: Emission Factors for CH_4 and N_2O Emissions from Non-Highway Mobile Sources (g/kg fuel)

Vehicle Type/Fuel Type	N_2O	CH_4
Marine Bunkers (Ocean-Going Ships)		
Residual*	0.08	0.3
Distillate*	0.08	0.3
Boats		
Residual	0.08	0.23
Distillate	0.08	0.23
Gasoline	0.08	0.23
Locomotives		
Residual	0.08	0.25
Diesel	0.08	0.25
Coal	0.08	0.25
Farm Equipment		
Gas/Tractor	0.08	0.45
Other Gas	0.08	0.45
Diesel/Tractor	0.08	0.45
Other Diesel	0.08	0.45
Construction		
Gas Construction	0.08	0.18
Diesel Construction	0.08	0.18
Other Non-Highway		
Gas Snowmobile	0.08	0.18
Gas Small Utility	0.08	0.18
Gas HD Utility	0.08	0.18
Diesel HD Utility	0.08	0.18
Aircraft		
Jet Fuel	NA	0.087
Av. Gas	0.04	2.64

* Methane emission factor value assumed based on value of diesel heavy oil in (IPCC/UNEP/OECD/IEA 1997)
NA (Not Available)

Table C-12: 1996 Emissions of NO_x, CO, and NMVOC from Mobile Sources (Gg)

Fuel Type/Vehicle Type	NO_x	CO	NMVOCs
Gasoline Highway	**4,752**	**46,712**	**4,709**
Passenger Cars	3,075	29,883	2,979
Light-Duty Trucks	1,370	13,377	1,435
Heavy-Duty Vehicles	295	3,267	259
Motorcycles	12	185	35
Diesel Highway	**1,753**	**1,318**	**283**
Passenger Cars	35	30	12
Light-Duty Trucks	9	7	4
Heavy-Duty Vehicles	1,709	1,280	267
Non-Highway	**4,183**	**15,424**	**2,201**
Boats and Vessels	244	1,684	460
Locomotives	836	102	44
Farm Equipment	1,012	901	207
Construction Equipment	1,262	1,066	184
Aircraft	151	861	161
Other*	678	10,810	1,144
Total	**10,688**	**63,455**	**7,192**

* "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.

Note: Totals may not sum due to independent rounding.

Table C-13: 1995 Emissions of NO_x, CO, and NMVOC from Mobile Sources (Gg)

Fuel Type/Vehicle Type	NO_x	CO	NMVOCs
Gasoline Highway	**4,804**	**47,767**	**4,883**
Passenger Cars	3,112	30,391	3,071
Light-Duty Trucks	1,378	13,453	1,478
Heavy-Duty Vehicles	301	3,741	297
Motorcycles	12	182	37
Diesel Highway	**1,839**	**1,318**	**290**
Passenger Cars	35	30	12
Light-Duty Trucks	9	7	4
Heavy-Duty Vehicles	1,795	1,281	274
Non-Highway	**4,241**	**15,278**	**2,207**
Boats and Vessels	244	1,674	436
Locomotives	898	103	45
Farm Equipment	1,007	885	207
Construction Equipment	1,265	1,053	184
Aircraft	150	855	161
Other*	678	10,709	1,175
Total	**10,884**	**64,363**	**7,380**

* "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.

Note: Totals may not sum due to independent rounding.

Table C-14: 1994 Emissions of NO_x, CO, and NMVOC from Mobile Sources (Gg)

Fuel Type/Vehicle Type	NO_x	CO	NMVOCs
Gasoline Highway	**5,063**	**54,778**	**5,507**
Passenger Cars	3,230	33,850	3,367
Light-Duty Trucks	1,503	15,739	1,731
Heavy-Duty Vehicles	318	5,013	375
Motorcycles	11	177	33
Diesel Highway	**1,897**	**1,316**	**300**
Passenger Cars	35	29	12
Light-Duty Trucks	9	7	4
Heavy-Duty Vehicles	1,854	1,280	284
Non-Highway	**4,485**	**15,308**	**2,376**
Boats and Vessels	233	1,663	575
Locomotives	859	104	45
Farm Equipment	1,113	998	229
Construction Equipment	1,443	1,146	204
Aircraft	146	830	159
Other*	692	10,566	1,164
Total	**11,445**	**71,402**	**8,184**

* "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.

Table C-15: 1993 Emissions of NO_x, CO, and NMVOC from Mobile Sources (Gg)

Fuel Type/Vehicle Type	NO_x	CO	NMVOCs
Gasoline Highway	**4,913**	**53,375**	**5,248**
Passenger Cars	3,327	35,357	3,427
Light-Duty Trucks	1,289	13,786	1,494
Heavy-Duty Vehicles	286	4,061	296
Motorcycles	11	172	31
Diesel Highway	**1,900**	**1,240**	**288**
Passenger Cars	36	30	12
Light-Duty Trucks	7	6	3
Heavy-Duty Vehicles	1,857	1,205	273
Non-Highway	**4,332**	**15,053**	**2,341**
Boats and Vessels	230	1,651	571
Locomotives	857	108	47
Farm Equipment	1,090	1,011	226
Construction Equipment	1,344	1,061	190
Aircraft	142	821	160
Other*	669	10,400	1,148
Total	**11,145**	**69,668**	**7,878**

* "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.

Table C-16: 1992 Emissions of NO_x, CO, and NMVOC from Mobile Sources (Gg)

Fuel Type/Vehicle Type	NO_x	CO	NMVOCs
Gasoline Highway	**4,788**	**53,077**	**5,220**
Passenger Cars	3,268	35,554	3,447
Light-Duty Trucks	1,230	13,215	1,440
Heavy-Duty Vehicles	280	4,145	303
Motorcycles	11	163	30
Diesel Highway	**1,962**	**1,227**	**288**
Passenger Cars	35	28	12
Light-Duty Trucks	7	6	3
Heavy-Duty Vehicles	1,920	1,193	274
Non-Highway	**4,226**	**14,855**	**2,314**
Boats and Vessels	239	1,639	568
Locomotives	858	113	49
Farm Equipment	1,078	993	223
Construction Equipment	1,256	999	178
Aircraft	142	818	162
Other*	653	10,293	1,134
Total	**10,975**	**69,158**	**7,822**

* "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.

Table C-17: 1991 Emissions of NO_x, CO, and NMVOC from Mobile Sources (Gg)

Fuel Type/Vehicle Type	NO_x	CO	NMVOCs
Gasoline Highway	**4,654**	**55,104**	**5,607**
Passenger Cars	3,133	36,369	3,658
Light-Duty Trucks	1,215	13,621	1,531
Heavy-Duty Vehicles	296	4,953	384
Motorcycles	10	161	33
Diesel Highway	**2,035**	**1,210**	**290**
Passenger Cars	34	27	11
Light-Duty Trucks	7	5	3
Heavy-Duty Vehicles	1,995	1,177	276
Non-Highway	**4,099**	**14,551**	**2,271**
Boats and Vessels	246	1,624	563
Locomotives	842	109	47
Farm Equipment	1,035	935	213
Construction Equipment	1,197	961	171
Aircraft	141	806	161
Other*	638	10,116	1,116
Total	**10,788**	**70,865**	**8,167**

* "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.

Table C-18: 1990 Emissions of NO_x, CO, and NMVOC from Mobile Sources (Gg)

Fuel Type/Vehicle Type	NO_x	CO	NMVOCs
Gasoline Highway	**4,356**	**51,332**	**5,444**
Passenger Cars	2,910	33,746	3,524
Light-Duty Trucks	1,140	12,534	1,471
Heavy-Duty Vehicles	296	4,863	392
Motorcycles	11	190	56
Diesel Highway	**2,031**	**1,147**	**283**
Passenger Cars	35	28	11
Light-Duty Trucks	6	5	2
Heavy-Duty Vehicles	1,989	1,115	269
Non-Highway	**4,167**	**14,622**	**2,270**
Boats and Vessels	235	1,600	555
Locomotives	843	110	48
Farm Equipment	1,028	969	214
Construction Equipment	1,268	1,023	181
Aircraft	143	820	163
Other*	650	10,099	1,109
Total	**10,554**	**67,101**	**7,997**

* "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.

Note: Totals may not sum due to independent rounding.